

Sudden natural death in later childhood and adolescence

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SUMMARY During a 6-year period 389 children and adolescents aged between 1 and 20 years died violently and 31 died suddenly, naturally, and unexpectedly in an area of southern Sweden. In about half of these 31 cases, death was caused by common infectious diseases—for example bronchopneumonia, myocarditis, or acute epiglottitis. In one group death was certainly sudden, but was caused by a known chronic disease—such as epilepsy or bronchial asthma. Three young men died from chronic heart disease, and one died from adrenal failure during or immediately after physical exertion. There were 4 cases of sudden, natural death for which the cause was unknown—that is 0.007 per 1000 live births. This figure is extremely low compared with the incidence of sudden unexplained infant death—that is deaths of infants aged between one week and one year.

Sudden, unexpected, and natural death in childhood and adolescence is rare.¹ Although the cause of sudden, unexpected, natural death in infants is the subject of comprehensive studies, deaths in children and adolescents have met with little interest.

Recently Schultz *et al.*² reported on such cases, necropsied at a department of forensic medicine in Germany, but it was not clear how the cases had been chosen for necropsy. However, it can be assumed that they were taken at random.

Swedish regulations stipulate that any unnatural death must be reported to the police. Natural death too must be reported if it occurs outside hospital and the cause cannot be established with certainty. If the doctor responsible for the treatment of the deceased is not available to issue a death certificate, a necropsy investigation has to be carried out at a department of forensic medicine.

This study was carried out primarily to gain understanding of the most common causes of sudden unexpected natural death in later childhood and adolescence. It was also done to establish if sudden inexplicable natural deaths, resembling sudden infant death syndrome, are confined to infants, as is generally supposed, or if they occur also in older children in whom morphological changes due to ageing and similar processes that might be interpreted or misinterpreted as a cause of death, are not likely to be found.

Material

The Department of Forensic Medicine in Lund is

responsible for an area of southern Sweden with a population of about 1 800 000 inhabitants, of whom about 450 000 are between 1 and 20 years old. According to the official Swedish statistics 111 566 persons died in the area between 1 January 1974 and 31 December 1979. Nine hundred and fifty-four persons were between 1 and 20 years old. In 522 cases death certificates were issued by either the doctor who treated the patient or a clinical pathologist. The remaining 432 cases were necropsied at the Department of Forensic Medicine. This study is not a prospective investigation; it is based on the records of each necropsy and on the microscopical findings.

The necropsy investigations were performed in a standardised manner with a gross and a microscopical examination. Material for chemical analysis was preserved if there was any suspicion of intoxication or if the cause of death was not obvious from the macroscopic findings, and in cases of traumatic death.

Material for bacteriological analysis was preserved if there was any suspicion of infectious disease. Police reports were generally based on a short investigation into the particulars of the fatality.

Results

In the present material of 954 deaths, death was unnatural in 389 cases (accidents, suicide, or homicide), that is in about 40%. In 522 cases death was due to clinically treated diseases. The remaining

43 cases of sudden natural death could be classified as follows:

Chronic disease. Known chronic disease was the cause of death in 12 cases. The physician was not available to sign a death certificate so each was necropsied. However they are of no interest to this study and are not mentioned further.

Death in 7 individuals was caused by chronic disease known to be consistent with an almost normal length of life, but also known to cause sudden death (Table 1). The group is dominated by bronchial asthma and epilepsy but includes one case of diabetes mellitus and one of familial cardiomyopathy (fibroelastosis cordis). Bronchial asthma is easily diagnosed at necropsy by the characteristic changes in the lungs. The diagnosis of grand mal seizures is based on the history and on the exclusion of other causes of death. The immediate cause of death in the diabetes mellitus case was acute myocardial

infarction caused by coronary thrombosis due to severe coronary arteriosclerosis.

Death from an apparently trivial disorder. Fourteen individuals had shown slight symptoms of an apparently trivial disease a short time before death and died suddenly and unexpectedly (Table 2). In 11 of them necropsy showed that death was the consequence of acute infectious disease—for example bronchopneumonia, acute epiglottitis, or myocarditis. In the remaining 3 (Cases 19, 20, and 21) the cause of death could not be explained.

Case 19

A 2-year-old previously healthy boy was found dead in bed after one week of fever and symptoms of 'common cold'. Necropsy showed macroscopically an otitis media and firm lungs. Microscopically the mucosa of the epiglottis contained a few polymorphonuclear leucocytes. There was oedema of the lungs and in a few lung alveoli clusters of alveolar

Table 1 *Death due to known diseases*

Case	Age (years)	Sex	Clinical diagnosis	Circumstances at death	Cause of death
1	2	Boy	Epilepsy	Found dead in bed	Epileptic attack
2	4	Girl	Epilepsy	Grand mal seizure	Epileptic attack
3	13	Girl	Familial cardiomyopathy	During bicycling	Cardiac failure due to fibroelastosis cordis
4	19	Girl	Diabetes mellitus	Found dead in bed	Coronary thrombosis and fresh myocardial infarction
5	12	Girl	Bronchial asthma	Asthmatic attack while bicycling	Asthmatic attack
6	16	Boy	Bronchial asthma	Found dead	Asthmatic attack
7	19	Boy	Bronchial asthma	Asthmatic attack at home	Asthmatic attack

Table 2 *Death after apparently trivial disorders of short duration in healthy individuals*

Case	Age (years)	Sex	Symptoms	Duration	Circumstances at death	Cause of death
8	2	Girl	Inflammation of upper respiratory airways	1 month	Found dead in bed	Bronchopneumonia
9	3	Boy	(Known epilepsy) upper respiratory airways symptoms	1 week	Found dead in bed	Bronchopneumonia
10	18	Boy	Fever	4 days	Died in bed	Bronchopneumonia
11	5	Girl	Fever, fatigue	1 week	Sudden apnoea at home, died in ambulance	Myocarditis
12	2	Boy	Fever	4 days	Died while being taken to hospital	Epiglottitis
13	16	Girl	Sore throat	1 day	Died while being taken to hospital	Epiglottitis
14	16	Boy	Gastrointestinal pain	10 days	Died in bed	Peritonitis due to gangrenous appendix
15	1.5	Boy	Fever, fatigue, vomiting	1 week	Died in hospital after 2 days' clinical treatment	Septic shock (β -haemolytic streptococci group B) evidence of inflammation of internal organs
16	2	Boy	Fever, fatigue	1 day	Found dead in bed	Meningitis (<i>Haemophilus influenzae</i>)
17	16	Girl	Sore throat	1 week	Found dead in lavatory	Ruptured spleen (generalised mononucleosis)
18	1.7	Boy	Fever	3 days	Found dead in bed	Bronchopneumonia
19	2	Boy	Fever, upper respiratory airways symptoms	1 week	Found dead in bed	Unexplained
20	14	Boy	Had finished 10-day treatment with antibiotics for common cold	10 days	Found dead in bed	Unexplained
21	17	Boy	Headache	1 day	Vomited and found dead in bed an hour later	Unexplained

macrophages. The toxicological screening analysis for alcohol, barbiturate, salicylate, and meprobamate was negative.

Case 20

A 14-year-old previously healthy boy, who had suffered from a 'cold' and on the day before had finished a 10-day penicillin treatment, was found dead in bed. The day before his death he felt only tired. Necropsy showed macroscopically firm lungs; microscopically clusters of macrophages were found in a few lung alveoli, and there was oedema of the lungs. The toxicological screening analyses for alcohol, barbiturate, meprobamate, chlorinated hydrocarbons, benzene, toluene, xylene, carbon-monoxide-haemoglobin, and substances extractable in acid and alkali were negative.

Case 21

A 17-year-old previously healthy boy who went to bed apparently without any symptoms of disease, woke up in the morning and felt sick. An hour later he was found lifeless in bed. Intense resuscitative efforts at hospital were unsuccessful. Necropsy showed no macroscopic changes except signs of resuscitation. Polymorphonuclear leucocytes in a few bronchi, oedema of the lungs, and clusters of alveolar macrophages in some alveoli were found microscopically. Slides stained with Mallory's PTAH revealed injury to the cytoplasm of the cardiac muscle cells suggesting fresh coagulation necrosis. The changes were regarded as an effect of the intense resuscitation. The toxicological screening analysis for alcohols, barbiturate, meprobamate, chloroform, trichloroethylene, benzene, toluene, and xylene was negative.

In none of these cases of unexplained death was bacteriological analysis performed.

Death without preceding symptoms. Five apparently

healthy individuals suffering from no acute illness before death, died without any indication of mental or physical stress (Table 3). However death was explained when necropsy showed clear pathological changes—such as myocarditis or epiglottitis.

Five apparently healthy individuals suffering from no acute illness before death, died during or immediately after physical exertion (Table 3). In 4 of them disease was present, but in the fifth the cause of death remained unknown.

Case 27

A previously healthy 13-year-old boy fell during a cross-country race at school. He was taken to hospital but was dead on arrival. At necropsy there was, macroscopically, a small atheromatous plaque in the left coronary artery. Microscopically, the heart muscle cell nuclei showed slight variation in size and there was oedema of the lungs and in some alveoli were clusters of alveolar macrophages. The cause of death could not be explained.

Case 28

During a cross-country race in his first week of military training a previously healthy 19-year-old boy stumbled and fell. Resuscitation could not save his life. He had been a keen athlete until about a year before death when, for unknown reasons, he stopped training. Fitness tests at enrolment during the time he was training showed excellent results for both strength and endurance. Necropsy showed macroscopically and microscopically fibrosis and calcification of the adrenals. The toxicological screening analysis for alcohol, barbiturate, and meprobamate was negative.

Case 29

A previously healthy 19-year-old boy was doing his military service. In his spare time he visited a sports ground where he practised athletics with a friend.

Table 3 *Death without preceding symptoms in apparently healthy individuals*

<i>Case</i>	<i>Age (years)</i>	<i>Sex</i>	<i>Circumstances at death</i>	<i>Cause of death</i>
22	1·7	Boy	Found dead in his carriage	Myocarditis
23	6	Girl	Immediately after a rest	Myocarditis
24	6	Boy	Found dead in bed	Myocarditis
25	12	Boy	Woke up, dropped dead	Probably septic shock (β -haemolytic streptococci group G), no changes in the internal organs
26	19	Boy	Found dead	Epiglottitis
27	13	Boy	Died during cross-country running	Unexplained
28	19	Boy	Died during cross-country running in military service	Addison's disease due to calcification of the adrenals
29	19	Boy	Died driving a car after athletic training	Myocardial fibrosis (isolated scar in the myocardium 8×2 cm, no changes in the coronary arteries)
30	19	Boy	Immediately after swimming	Cardiac hypertrophy (520 g)
31	19	Boy	Died during cross-country running in military service	Stenosis of the left coronary artery due to wall fibrosis and with two myocardial scars (10×3.5 and 8×4 cm)

Driving his own car home, he complained of fatigue and dizziness. He stopped the car and fell over the steering-wheel, lifeless, and could not be resuscitated. Six months earlier electrocardiogram (ECG) recordings had been made at enrolment. These showed signs of the Wolff-Parkinson-White syndrome of pre-excitation and a slight lowering of the ST-T segment. He was given an exercise stress test which showed lowering of the ST-T segment during and after bicycling. Necropsy showed an 8×2 cm myocardial scar in the anterior wall of the left ventricle. There were no pathological changes in the coronary arteries. The toxicological analysis for alcohol and barbiturate was negative.

Case 30

A previously healthy 19-year-old boy went swimming with some friends. He came out of the water after a 100-metre swim and fell on his face. His friends were unable to resuscitate him. He had done military service the previous year without any problem. The ECG record at enrolment showed signs of the Wolff-Parkinson-White syndrome of pre-excitation, and also signs of left ventricular hypertrophy. The recording was regarded as 'not definitely abnormal'. Necropsy showed pronounced cardiac hypertrophy (520 g), oedema of the lungs, and congestion of the internal organs. The toxicological screening analysis for alcohol, barbiturate, and phenothiazine was negative.

Case 31

A 19-year-old boy stumbled and fell during a cross-country race while doing military service. He could not be resuscitated. He had been a patient at a cardiology clinic since aged 4, firstly because of a systolic murmur, and latterly because of fatigue and non-specific pain in the chest. He had been catheterised twice because mitral valve insufficiency was suspected, but the results were inconclusive. He had been given several exercise stress tests which showed low work capacity and ST-T lowerings possibly of coronary type. During these tests he had not mentioned any pain in the chest and his last test had shown regression of the ST-T—changes and was regarded as 'not definitely abnormal'. He had been allowed to do military service because of his ambition to become an air force pilot. At necropsy an enlarged heart (445 g) with a fibrotic scar measuring 10×3.5 cm in the anterior wall and a scar measuring 8×4 cm in the posterior wall of the left ventricle could be seen. Microscopically, these areas consisted of fibrous tissue, surrounded by some muscle cells showing signs of fresh infarction (Mallory's PTAH stain). There was a severe stenosis in the left coronary artery immediately below its

origin, which microscopically consisted of fibrous tissue and a few macrophages. The toxicological screening analysis for alcohol, barbiturate, and meprobamate was negative.

Discussion

Sudden natural death in young people is a subject poorly represented in medical papers.³

The material presented here is based on the necropsies at a department of forensic medicine. Such material is, of course, a selection of deaths. It contains all unnatural deaths and sudden natural deaths, even if death occurred a short time after admission to hospital in seemingly healthy individuals.

The large number of unnatural deaths in this age group is in accordance with other studies.⁴ The low number of sudden, natural, unexpected deaths is striking. During a period of 6 years, there were only 31 unexpected deaths in a total population of about 1 800 000 of whom about 450 000 were of people aged between 1 and 20 years. In view of Swedish regulations concerning the issuing of death certificates, and the manner in which such regulations are complied with, it is unlikely that any further case of sudden natural and unexpected death occurred.

In this material there was a group of patients who suffered from chronic diseases such as bronchial asthma and epilepsy. Although such diseases are compatible with a normal lifespan, sudden death is recognised. Deaths in this group were regarded as sudden and unexpected by the physician responsible for the deceased and by the relatives.

It is known that persons suffering from chronic heart disease may die suddenly, during or immediately after mental or physical stress. In this material were 3 such cases. They demonstrate, as shown in other studies,^{5,6} that severe cardiac disease can remain undetected despite a thorough medical examination.

In 2 cases in which heart disease was the cause of death, previous ECG recordings had shown the Wolff-Parkinson-White syndrome of pre-excitation. In Sweden the Minnesota code is used for the interpretation of ECG recordings. The code states that in cases of pre-excitation, the finding of changes in the QRS-complex or in the ST-T segment is difficult to evaluate. In both cases there was a lack of subjective symptoms, and this fact, together with the recommendations of the code, were obviously why the ECG changes had not been considered further.

In Case 31, thorough examinations at a cardiology clinic had been unable to establish a diagnosis. Obviously the contradictory results in the exercise stress tests together with the boy's eagerness to

become an air-force pilot had mitigated against such a finding. Pathologically it was difficult to ascertain the genesis of the coronary artery stenosis. The changes bore a resemblance to infantile periarteritis nodosa, endomyocardial fibrosis, and arteriosclerosis, but the stenosed part of the artery lacked inflammatory changes, lipid deposits, and calcification.^{7 8}

It is well known that exertion can cause sudden death in cases of adrenal insufficiency. It is striking that a 19-year-old boy with calcifications of the adrenals did not show any symptoms of this disease shortly before death. He had performed a fitness test about a year earlier during a cross-country race and the results had been excellent in every respect. When and how had this calcification occurred? Snelling⁹ indicates that calcification of the adrenals can occur in a matter of weeks and as a consequence of spontaneous bleeding. That study however, was performed in infants and it is not known how quickly calcification develops in young adults. Nevertheless, it seems possible that the pathological changes in the adrenals of the actual case had occurred after the test. The case stresses that thorough medical examinations should be done immediately before military training.

In view of the total material it is striking that as many as 16 out of the 31 cases of sudden natural death were caused by infectious disease. However, other studies also confirm this observation and in a study of children below age 10, 80% of sudden natural deaths were caused by infectious disease.¹⁰ In a study of adults between 20 and 45 years of age, 25% of sudden natural deaths were caused by infectious disease.¹¹ These studies and the results presented here indicate that infectious disease is a leading cause of sudden natural death in young individuals. It is known that severe infectious disease—for example myocarditis or epiglottitis—which may be fatal, often are preceded by mild symptoms.

It is known that bacterial infection can cause death, with only very modest changes in the internal organs,¹²⁻¹³ and this was so in the two cases of probable septic shock presented here. This fact and the knowledge that symptoms of infectious diseases are often slight, ought to make the preservation of material for bacteriological culture obligatory in cases of sudden natural death in children and adolescents if no clear reason for the death can be found.

In 4 of the cases presented here, the cause of death could not be established. Material for bacteriological culture was not preserved and infectious disease cannot be ruled out, although there was no evidence. If these cases are regarded as inexplicable,

3 of the cases are similar to cases of sudden infant death, considering the circumstances at death. However, the incidence of inexplicable deaths in this age group is extremely low, only about 0.007 per 1000 live births, to compare with that of sudden infant death syndrome, which in Sweden is 0.6 and in USA 2.9.¹⁴

Thus, most deaths in this age group are caused by infectious disease. It is striking that infections that lead to death, have such discrete manifestations. In none of the cases where infectious disease caused death did physical exertion contribute to the fatality. In the 5 cases, where death occurred in connection with physical activity, the cause was chronic cardiac disease in 3 cases, unexplained in one case, and Addison's disease in one case. Unexplained deaths, similar to sudden infant death syndrome are few and somewhat questionable, but their existence cannot be ruled out from this study.

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